Participatory agro-ecosystem analysis and identification of problems in Garhkundar-Dabar Watershed of Central India

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ABSTRACT : The studies on participatory agro-ecosystem analysis and identification of problems conducted in Dabar-Garhkundar watershed of Tikamgarh, M.P. are presented in this paper. This watershed has an area of 850 ha and supports nearly 191 farm families having 2648 animal resources. Rainfed agro ecosystem covers the major area and hardly 20% of the cultivated area is under irrigation and that too supplemental only. The cropping systems are dominated by cereals as seen from crop diversification which shows that in a particular year the cultivated area is highest under cereals (46%) followed by pulses (22%), oilseeds (20%) and others (12%). The productivity of the crops is low. The soil types of the watershed are locally known as Rakar and Parwa which are the variants of the red soils and are poor in fertility due to coarse texture, shallow depth, low water retention capacity, low organic matter and multiple slopes. The watershed area is rich in floral and animal wealth and the number of animals per household worked out to be 13.9 while the number of animals per person was 2.9. They play an important role in livelihood security of the people through drought proofing. However, the milk productivity in terms of litres/day/animal is low and varies between 3-5 for buffaloes, 1-2 for cows and 0.250-0.500 in case of goats. While analyzing the system properties and problems, "low productivity of crops and animals due to water scarcity" was emerged as the topmost problem and based on this, our team proposed a "model watershed project on natural resource management through agroforestry interventions" to address the problems and bring livelihood security and sustainability in agricultural production in the area.

Keywords: *Bundelkhand, bioresource flow, participatory agro ecosystem, watershed.*

1. INTRODUCTION

Participatory Rural Appraisal (PRA) was conducted in the Garhkundar Dabar watershed in 2006 to identify the resources, needs, problems, opportunities and finally the research hypothesis. The present study was conducted during the 1st quarter of 2006 in the villages Garhkundar, Dabar, Rautiana, Shivrampur, Sakuli, Ganj, Ubora and Shyamsi of Niwari in Tikamgarh district of Madhya Pradesh. This area represents typical physiography and economy of Bundelkhand region. PRA was conducted by an interdisciplinary team of scientists to build rapport with the stake- holders by way of interacting and making them aware about the programme and ensure interactive participation and interdisciplinary research approach. The system tools and methods were used for identifying indigenous natural resources, their types, relationship and key decision making systems in the villages. The objectives of the present study were - (a) Estimating land use, resources available, needs, opportunities and indigenous technical knowledge in the area, (b) Understanding farming system and identifying system problems and solutions thereof and (c) Training local stakeholders in participatory data collection procedures and sensitizing and motivating them.

2. MATERIALS AND METHODS

As the study was completely participatory and interdisciplinary, the following procedures were used to invoke participation and data collection.

2.1 Transect walk

Three transect walks through the watershed were conducted along with some key informants (KIs) and discussions during the walk helped to identify indigenous natural resources types (land, soil, water, vegetation etc.) and elements of system to find contrast in various niches and reasons thereof, as suggested by Conway (1985) and Mettrick (1993).

2.2 Agro-ecosystem mapping

The key informants (KIs) along with team members identified resources and location, their utility and decision system and drew Agro-ecosystem map on the ground and later translated it to the drawing sheet. The farmers discussed various decision making systems while constructing the maps. Other useful informations about the area were also collected while preparing the agro-ecosystem map as suggested by Hoque (1984).

2.3 Problems analysis

Agro-ecosystem analysis helped to carry out problems analysis. The problems in the agriculture production system were identified, analysed (Mettrick, 1993) and ranked on the basis of various

criteria identified by the farmers and the intensity of yield loss (Sabarathnam and Vennila,1996). There was an indepth analysis of the topmost problems in the form of problem-solution trees constructed after focused group discussion with key stakeholders.

The data are collected through Participatory Rural Appraisal (PRA) and personal interactions with farmers in the watershed villages. Few information are also obtained through household surveys and confirmed with line departments of the government.

3. RESULTS AND DISCUSSION

3.1 Agroecology

The watershed area lies in Niwari block of Tikamgarh district in Madhya Pradesh. The area represents Bundelkhand which consist of 13 districts of Uttar Pradesh and Madhya Pradesh. The watershed area falls between 78° 54'44" to 78° 52'39" E longitude and 25° 26'23" to 25° 28'32" N latitude with an altitude of 230-280 m above mean sea level. The watershed area experiences tropical semi arid climate where temperature ranges between 5-48°C, the mean annual rainfall is around 900 mm, and the mean annual potential evapo-transpiration is over 1600 mm, which is more than the rainfall received. In general, May-June are the hottest while December-January are the coldest months of the year. The area has highly undulating, eroded and dissected topography. The total area of the watershed is 850 ha which ultimately drain into river Betwa. It supports nearly 900 human and 2650 animal populations directly. Palsaniya, *et.al.* (2008) while studying livelihood support system of the watershed dwellers revealed that nearly 19.5% population derives its livelihood from agriculture including animal husbandry, 56% from agriculture as well as labour work in and around the watershed area, 21% derive their subsistence solely from labour activities, 1.2% from government services while remaining 2.3% are engaged in other occupations like driving, tailoring, pot making, carpentry etc.

3.2 Land utilization pattern

The total area of watershed is 850 ha out of which 35.3% (296 ha) is cultivated area. The forest is though degraded but constitutes nearly 54.1% (463 ha) of the total area. Most of the settlement area is out side or at the periphery of the watershed boundaries. Irrigation is inadequate in the watershed area and the main sources of irrigation are wells, though a sizeable amount of water is also lifted from the Chhinga Nallah and its contributory channels by digging pits. Not more than 20% of the cultivated area is under irrigation that too is supplemental only. The PVC pipes are widely being used for conveying the water for irrigation. Sprinkler and drip irrigation system are not in use in the watershed area. Hand pumps and wells are found to be the main source of drinking water which often run dry during summers, thus causing scarcity of drinking water. As far as land holding size is concerned, marginal and small land holdings together comprises 86.3% and rest 13.7% are medium. There are no large land holdings in the watershed area.

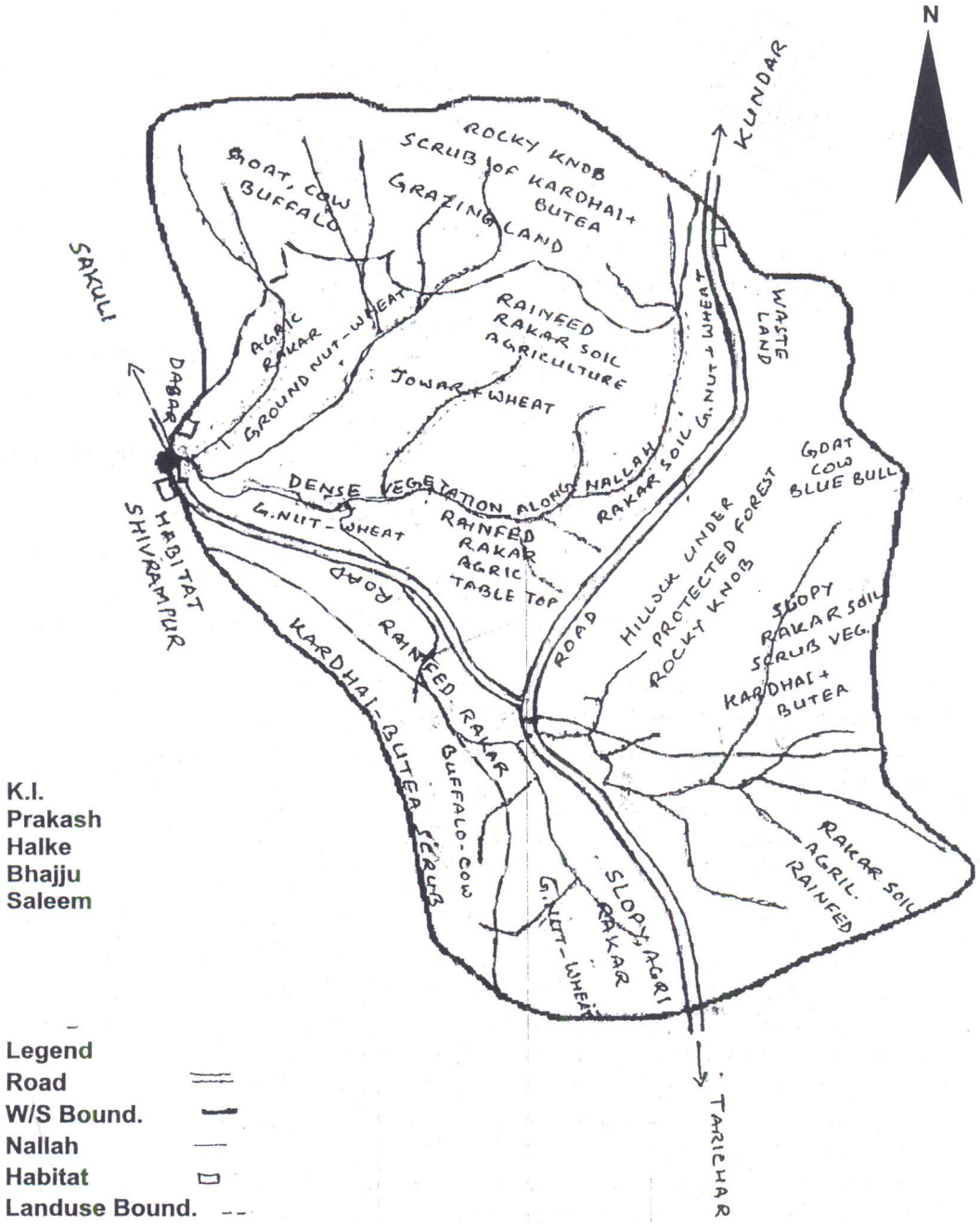
The land use is mainly determined by the soil types and nearness to the water course. The soil types of the watershed are locally known as Rakar and Parwa which are the variants of the red soils. Rakar soils (Alfisols) are the coarse textured, gravelly, shallow, reddish to brownish in colour, poor in fertility and water retention capacity. Rakar soils occupy the upland areas and suitable for cultivation of groundnut, millets, jowar, urd, moong etc. The Parwa soils (Entisols) are grey to brownish, loam to sandy loam in texture and medium in depth. Almost all crops are grown on Parwa soils, but the main crops are soybean, til, urd, moong, wheat, gram, mustard and vegetables like brinjal, tomato, ladies finger and chillies etc.

There is no established agroforestry system in the watershed area. However, trees like Dhak, Neem, Ber, Mahua, Babul and Mango are found here and there on field boundaries, near wells and habitats. The watershed area is bestowed with important trees like Palas, Kardhai, Babul, Shisham, Chirol, Reonjha, Neem, Khajoor etc. which are found in forest, along Nallah and field boundaries. The forest area is in highly degraded condition and mainly confined to hillock area.

Sorghum, groundnut, till and urd are the main Kharif crops covering nearly 35, 20, 18, and 15% of the net sown area respectively while wheat, pea, mustard and gram are the major Rabi crops with respective value of 40 , 20, 15 and 10% in net sown area (Fig. 1 and 2). The other crops of interest are moong, pigeonpea, potato, brinjal, chilli, tomato, maize etc. The comparative land cultivation given in Fig. 3 shows that in a particular year the cultivated area is highest under cereals (46%) followed by pulses (22%), oilseeds (20%) and others (12%) which comprises vegetables, fodder crops, fruits etc. The productivity of the crops is low as shown in Table 1: The low productivity of these crops is attributed to low and declining soil fertility, poor input use and responsiveness and depleting water table.

Most of the Nallah banks are covered with fairly dense vegetation. The important weed identified by the farmers are *Parthenium hysterophorous,*

Agro-Ecosystem Map of Garhkundar-Dabar Watershed



K.I.
Prakash
Halke
Bhajju
Saleem

Legend
Road
W/S Bound.
Nallah
Habitat
Landuse Bound.

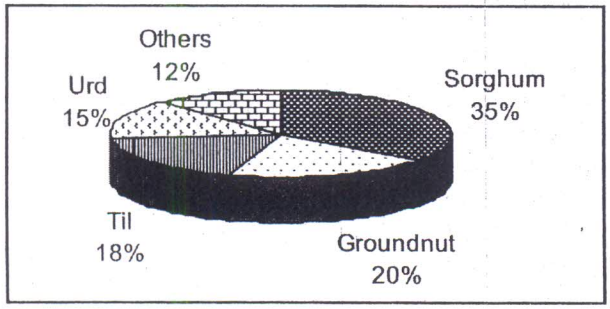


Fig. 1. Net area sown under different crops during Kharif

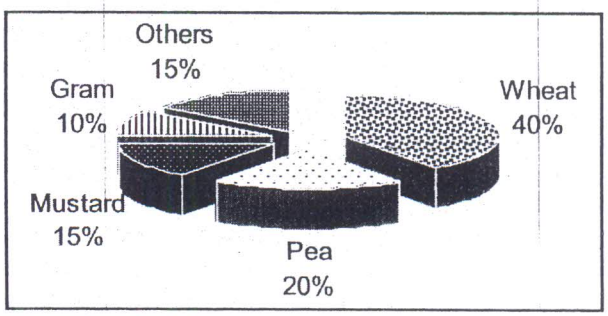


Fig. 2. Net area sown under different crops during Rabi

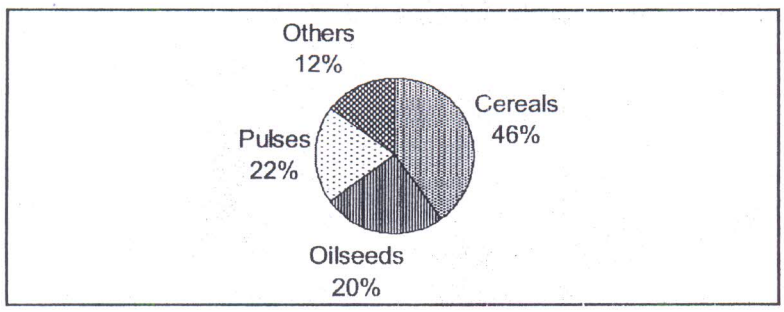


Fig. 3. Comparative areas under different Crops

Table 1. Productivity of major crops in watershed area

Crop	Productivity (kg/ha)
Wheat	2200
Sorghum	1000
Gram	1200
Groundnut	1200
Pea	1500
Urd	600
Mustard	1000
Til	500

Xanthium strumarium and *Lantana camara* on waste and cultivated lands while *Asphodelus tenuifluis, Melilotus, Chenopodium,* Jangli Gobi, Jangli Matar , *Cynodon, Cyperus,* etc. are major weeds under cultivated condition. Sorghum + Urd / Til, Sorghum + Aarhar, Urd / Mung + Til, Wheat + Mustard and Gram + Mustard are the common inter/mixed cropping system followed in the watershed area.

3.3 Livestock production system

Livestock play an important role in the livelihood and subsistence of the people in watershed area. The total animal wealth in watershed area is around 2648 out of which 57.2% are goat followed by 16.8% sheep, 11.3% buffalo, 4.8% cattle, 3.5% bullocks and 6.4% poultry (Table 2). The small ruminants, i.e., goat and sheep together comprise 74% of the total animal population whereas buffalo and cattle constitute 16.1% of total animal wealth.

Most of the animal breeds are non-descript or Desi and have low milk productivity. The milk productivity in terms of litres/day/animal varies between 3-5 for buffaloes, 1-2 for cows and 0.250-0.500 in case of goats. Still they contribute significantly in rural livelihood security and provide a kind of drought proofing. The number of animals per household worked out to be 13.9 while the number of animals per person was 2.9. This signifies animal's contribution in the rural livelihood in terms of milk, meat, eggs, income and employment. Small ruminants like goat and sheep rearing is economically very viable and profitable. The problems in livestock production system are low productivity, infertility and poor fodder resources in the area. A peculiar system of animal rearing called Annapratha is common in the watershed wherein farmers leave their animals for free grazing which is an obstacle in crop production

Table 2. Animal resources in the watershed villages, 2006.

Animal	Animal number								Milk Productivity (lit/day/animal)
	Sakuli	Dabar	Shivrampur	Rautiana Gunj	Kundar	Ubora,Shyamsi	Total	%	
Buffalo	56	88	17	6	110	22	299	11.3	3-5
Cow	25	16	42	5	30	10	128	4.8	1-2
Goat	250	280	149	40	680	115	1514	57.2	0.250-0.500
Sheep	50	55	-	10	300	30	445	16.8	-
Poultry	-	-	40	65	50	15	170	6.4	-
Bullock	16	14	26	6	22	8	92	3.5	-
Total	397	453	274	132	1192	200	2648	100	-

system and tree plantation particularly during Kharif season.

3.4 Niches in the system

In general, the watershed is surrounded by small rugged hillocks. The watershed can grossly be divided into three niches based on topography and land use, i.e.; agricultural land where crops are grown; hillock/forest/wastelands which are predominantly occupied by Dhak and Kardhai mixed forest which is a source of fuel wood and animal grazing and the Nallas covered with thick vegetation (see Watershed Transect).

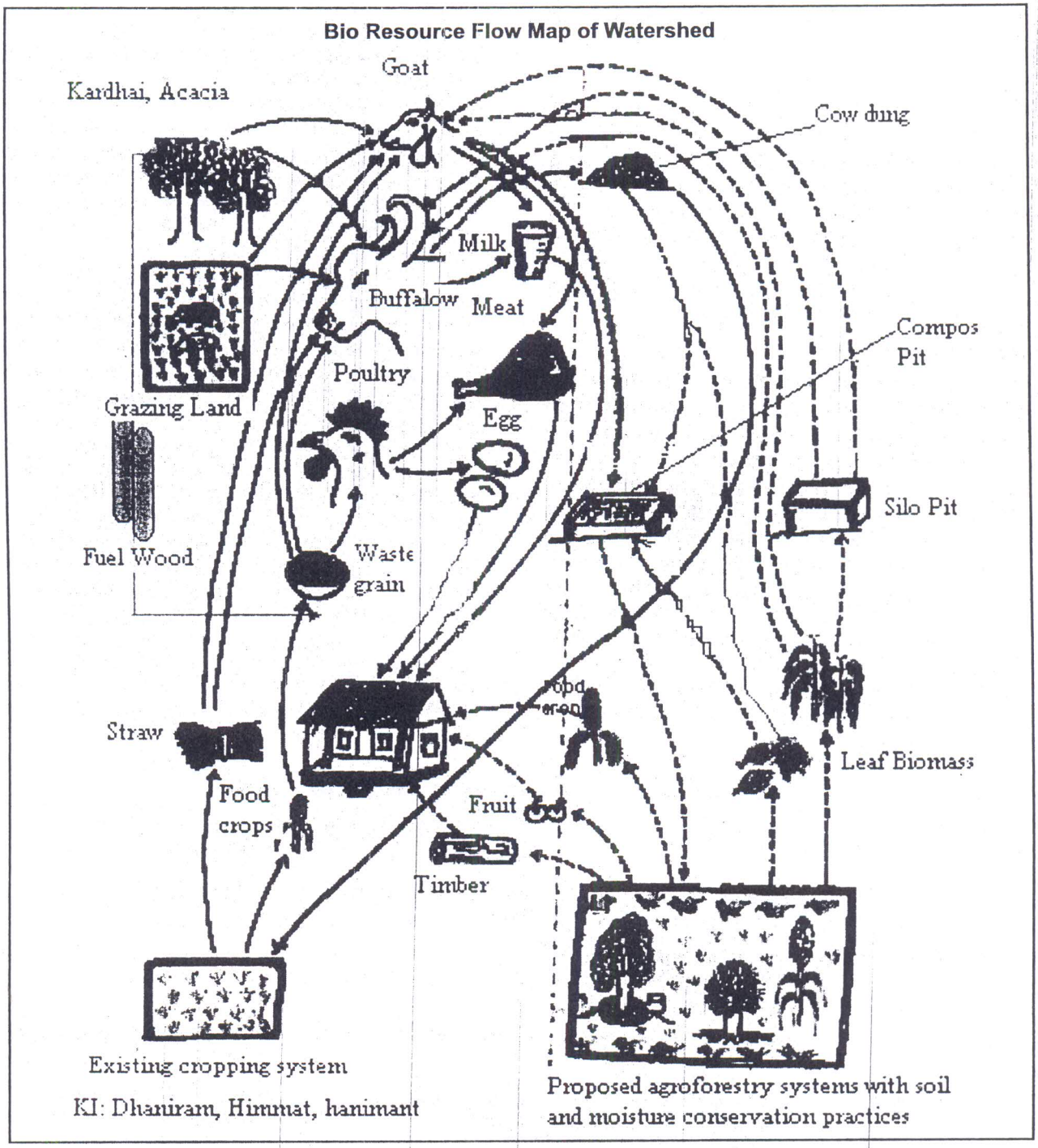
3.5 Bio resource flow

Bio-resource flow diagram essentially reflects the inflow and outflow of different farm produce and their by-products in relation to household. It represents the interrelationships between different farm enterprises that enables holistic approach for better utilization of bio-resources to maximize the profit and livelihood augmentation. The diagram is made on the basis of information obtained from representative farmer (KIs) and through survey of the villages. The study was carried out to identify the all possible bio-resources of agricultural and animal husbandry produces and their byproducts. It was constructed considering the existing common practices as well as possible proposed way for better utilization of bio-resources.

The key informant was a representative of the majority of the farmers in the watershed villages practicing a mixed type of farming system including both agriculture and animal husbandry. The farmer had small agricultural land and animals including buffalo and goats. Buffaloes are fed with straw, cultivated fodder and seasonal grazing. Goats were mainly dependent on forage, free grazing, top feed and fodder available from the land. The farmers were also using available crop residues and wastes for animal feeding. The major return back from animals was in terms of milk from buffaloes and goats and meat from goats. The farmer was also using the animal waste for agricultural land as organic manure for raising crops. A sizable portion of animal dung is used as fuel source. This diversion of animal dung from manure source to fuel source is the major cause of depleting soil fertility and increasing reliance on chemical fertilizers. Inadequate field bunding accompanied with multidirectional complex slopes has resulted into high erosion exposing sub soil which is low in fertility and water retentivity. With this complex situation of less profitable and seasonal agriculture, appropriate agroforestry interventions on watershed basis were proposed with the aim of optimum utilization of agricultural land to directly support the farmer's livelihood in terms of crop, fruit, timber and employment. Agroforestry land use, in addition, will check

Watershed Transect

Particulars	Agricultural land	Hillock/Forest/ Wastelands	Nallas
Land use	Crop fields	Degraded forests, grazing lands	Covered with vegetation, grazing, Water source
Soil	Rakar & Parwa,	Gravelly, boulders, rocky, Rakar	Eroded, sloppy
Crops	Sorghum, groundnut, urd, til, mung, pea, wheat, mustard, gram, potato, brinjal	-	-
Trees	Butea, Ber, Neem, Shisham,	Kardhai, Butea	Date Palm, Semel, Butea, Acacia, Chirol
Grasses & Weeds	Asphodelus, Chenopodium, Cyperus, Cynodon, Argemon, Melilotus	Lantana, Parthenium, Aristida, etc.	Themeda, Aristida, Lantana, Partheniu
Animals	Squirrel, rats, reptiles etc.	Vanroj (Neelgai), rabbit, squirrel, jackal, fox	Vanroj, rabbits, reptiles etc.
Water resource	Wells, from Nalla by bolls,	No	Pits, seasonal
Problems	Water scarcity, soil erosion, poor soil fertility, stray animals	Erosion, water scarcity, excessive grazing etc.	Erosion, over grazing, illegal tree cutting etc.
Opportunities	Watershed development, agroforestry	Tree regeneration and afforestation, silvipasture, trenching and bunding	Check dams, gabions, afforestation, grassed waterways etc.



erosion and enrich soil through litre addition, thus restore water holding capacity.

Farmer will also get fodder for his animals. The animal dung can be better utilized by converting it into compost along with other farm and household wastes. The water harvesting measures will provide drought proofing to the area. Similarly, the proposed agroforestry interventions will bring sustainability in the agriculture and will provide livelihood security by fulfilling the multiple needs of the farmers by providing food, fodder, fibre, fuel and timber. It will also enhance the employment opportunities in the area.

3.6 Problem analysis

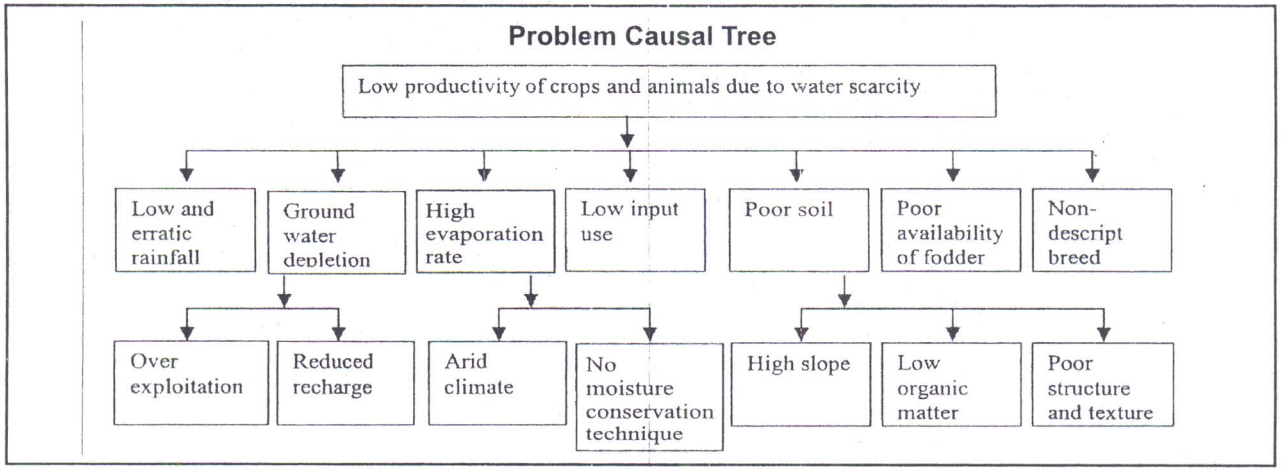
While analyzing the system properties, various researchable and non-researchable problems were identified. "Low productivity of crops and animals due to water scarcity" was emerged as the topmost problem based on ranking as per importance. Though the watershed area receives on an average 900 mm annual rainfall but since 2004, it received nearly half of the annual average. The winter rainfall

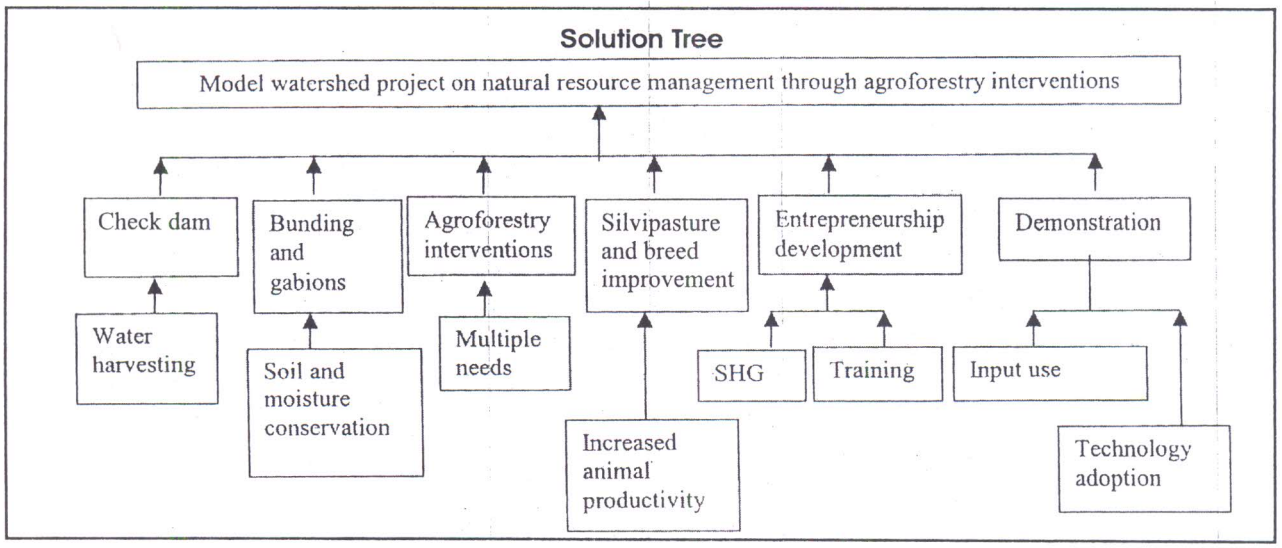
has become rare phenomenon. The monsoon has become erratic and unpredictable. The agricultural situation further aggravated by depleted ground water. Moreover, the villagers are not adopting any of the water harvesting structures to recharge the ground water table. Due to semi-arid climate, the rate of evaporation is higher. Further, the runoff losses and soil erosion is very high due to sloppy land and poor vegetation cover.

These can be effectively managed by adopting scientific soil and water harvesting structures like check dams, gabions, bunding, khadins, mulching, contour cultivation, cover crops, vegetative barriers, etc. The adoption of scientific packages of practices was found to be very low.

The productivity of animals was very low due to non-descript breeds and poor availability of fodder. Grazing lands have either been encroached or distributed amongst landless. As such, only forest land is available for animal grazing which supports only Aristida grass of lowest ecological order. They are mere roaming lands for cattle and buffaloes. In general, it was observed that watershed area faces severe water scarcity threatening to their livelihood security through reduced crop production and fodder shortage affecting animal production and encouraging migration in search of better livelihood.

After identification of critical factors and major problems in watershed area, our team proposed the project entitled "Model watershed project on natural resource management through agroforestry interventions at Garhkundar, Tikamgarh, M.P." to address the problems and bring livelihood security and sustainability in agricultural production in the area. This project is capable of addressing the multiple problems of the area through water harvesting, soil and moisture conservation practices, introduction of improved agroforestry practices, development of silvipasture, breed improvement, demonstration of improved agrotechniques for increasing the productivity and input management and development of entrepreneurship through framing SHGs, trainings and capacity building. The construction of check dams will directly increase the employment opportunities in the area. A participatory indepth study through problem and solution tree of the topmost problem has been illustrated through flowcharts.





4. CONCLUSION

Participatory Rural Appraisal (PRA) helped in quick assessment of problem, critical factors responsible for low productivity and possible solutions thereof. The team got an insight for locating water harvesting structures, location of critically eroded areas for bunding, selection of ideal sites for demonstration of improved agrotechniques and agroforestry landuse, identification of progressive and willing farmers to accept changes, rural leaders to influence society for bringing in mindset change. The exercise also helped in motivating farmers and finalizing course of action to successfully implement the project in the field.

ACKNOWLEDGEMENTS

The authors are thankful to farmers of watershed area for their active cooperation with the team during study and also to the Indian Council of Agricultural Research for financial support for the watershed development programme.

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